Forces and Motion
PS-5 The student will demonstrate an understanding of the nature of forces and motion.

PS-5.2 Use the formula v = d/t to solve problems related to average speed or velocity.
Taxonomy Level: 3.2-C Apply Procedural Knowledge

Key Concepts:

Average speed (v)	Average velocity (v)
Distance (d)	Displacement (d)
Elapsed time (t)	

Previous/Future knowledge: 8th grade students used the formula for average speed, v = d/t to solve real-world problems (8-5.2). In 8th grade the concept is "speed" even though the variable is represented by a "v". In PS-5.1 students develop a conceptual understanding of the idea that direction is an important aspect of the motion of an object and compare the concepts of distance and displacement. The term "velocity" is used for the first time, and students differentiate speed and velocity (PS-5.1). This indicator addresses the mathematical dimension of motion solving for average speed or velocity. Physical Science students will need to rearrange the equation v = d/t to solve for any of the variables.

It is essential for students to

- Understand the correct context for the variables in the word problem when using the equation v = d/t.
  - In the equation, "v" can represent either velocity or speed and "d" can represent either displacement or distance, depending on the context of the problem. The differences are addressed in PS-5.1
  - The term "speed" or "velocity" refers to average speed or velocity.
  - Students must determine the "given" information in a problem using the correct units. See sample table:

Variable	Abbre-viation	Units	Direction required?	Examples	
Speed	v	distance/time	No direction	m/s	22 cm/yr
Velocity	v	distance/time	With direction	m/s north,	36 km/h west
Distance	d	distance	No direction	15m	30.0 km
Displacement	d	distance	With direction	546 km down	24.9 m west
Time	t	time	NA	15 s	32 days

- Use the formula, v = d/t.
  - Students must be able to calculate average speed.
    - When calculating *average speed* using v = d/t: the average speed for the trip equals the total distance divided by the total time. Ignore the direction of the motion.
  - Students must be able to calculate average velocity.
    - When calculating *average velocity* using v = d/t: the average velocity equals the total displacement divided by the total time.
      - The total displacement may be different from the total distance.
      - When indicating the average velocity, direction must be given and the average velocity will have the same direction as the total displacement.

        - The total displacement is the (straight line or shortest) distance and direction from the starting point.
        - If the direction of the motion is changing, the velocity will not be constant even if the speed is constant.
    - Students must be able to rearrange the equation to solve for any of the variables. Example: $d = vt$, or $t = d/v$
    - The instantaneous velocity at any point will not necessarily be the same as the average velocity.

Teacher note: The students are only responsible for velocity problems in which the total or final displacement is given.

It is not essential for students to

- Convert Standard English units to metric units;
- Solve problems involving scientific notation;
- Calculate average velocity using displacement when total displacement is not given; (They do not need to solve for total displacement first.)
- Solve velocity problems involving vector addition.

Assessment Guidelines:

The objective of this indicator is to ***use*** the formula $v=d/t$ to solve problems, therefore the primary focus of assessment should be to apply the velocity equation to a novel word problem or set of laboratory data, not just repeat problems that are familiar. -

In addition to *use*, assessments may require that students:

- *Apply* procedures for manipulating the velocity equation;
- *Recall* the differences between speed and velocity as to whether a direction is needed;
- *Identify* the units needed in the solution to a problem.